RO·MICRO

From CoBra to
iPhone and Vision Pro

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# Ro-Micro | Microprocessor Evolution in 52 years

Processor	Launch	Discount.	Transistor	Clock	Technology	Pins	Data Bits	Addr. Bits
Intel C4004	Nov. 1971	1981	2,300	0.750 MHz	10 μm	16	4	12
Intel C8008	Apr. 1972	1983	3,500	0.800 MHz	10 μm	18	8	14
Intel 8080	Apr. 1974	1990	4,500	3.125 MHz	6 μm	40	8	16
Motorola 6800	1974		4,100	2.000 MHz	8 μm	40	8	16
MOS Tech 6502	1975		3,510	3.000 MHz	8 μm	40	8	16
Xilog Z80	Jul. 1976	2024	8,500	8.000 MHz	4 μm	40	8	16
Intel 8086	1978	1998	29,000	10.000 MHz	3 μm	40	16	20
Apple M3 Max	Oct. 2023		92 x 10^9	4.050 GHz	3 nm	thousands	many	many

Feature	Intel 4004	Apple M3 Max	Ratio
Cores	1	12P + 4E + 40GPU (x128 ALUs) + 16NE (x256 MACs)	9,232
Transistors	2,300	92,000,000,000	40,000,000
Clock	750 KHz	4.05 GHz	5,400
IPC	1/8	8	64
Geometry	10 μm	3 nm	3,333
Memory Size	4 KB	128 GB	33,554,432
Memory B/W	0.1 MB/sec	409.6 GB/sec	4,096,000
Media Engines	0	Video Codecs, ProRes, ISP, Pixel Processors	infinite

**Moore's Law: The number of transistors on microchips doubles every two years**

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important for other aspects of technological progress in computing – such as processing speed or the price of computers.

Transistor count
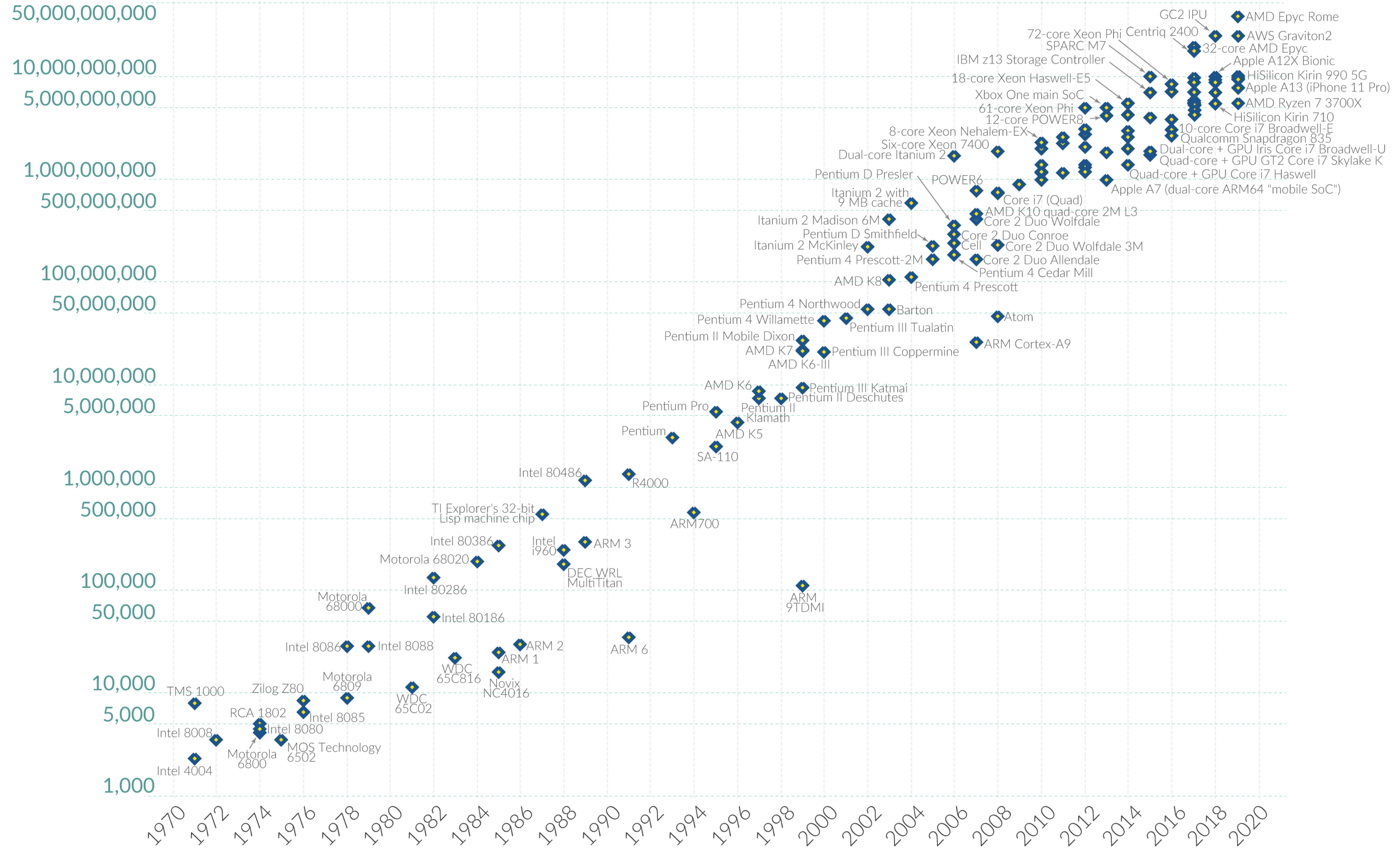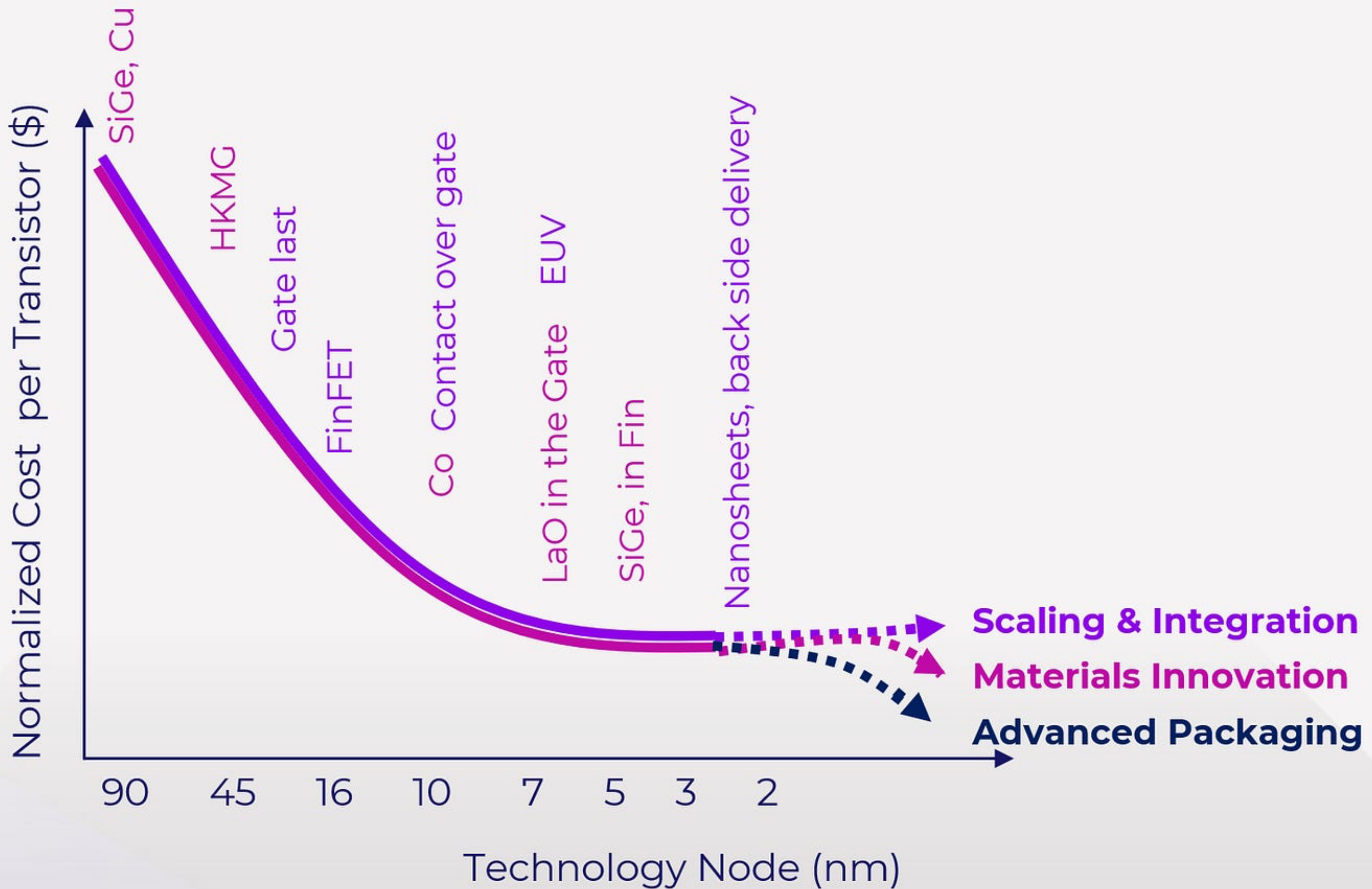
As transistors get smaller, their power density stays constant, so that the power use stays in proportion with area; both voltage and current scale (downward) with length.
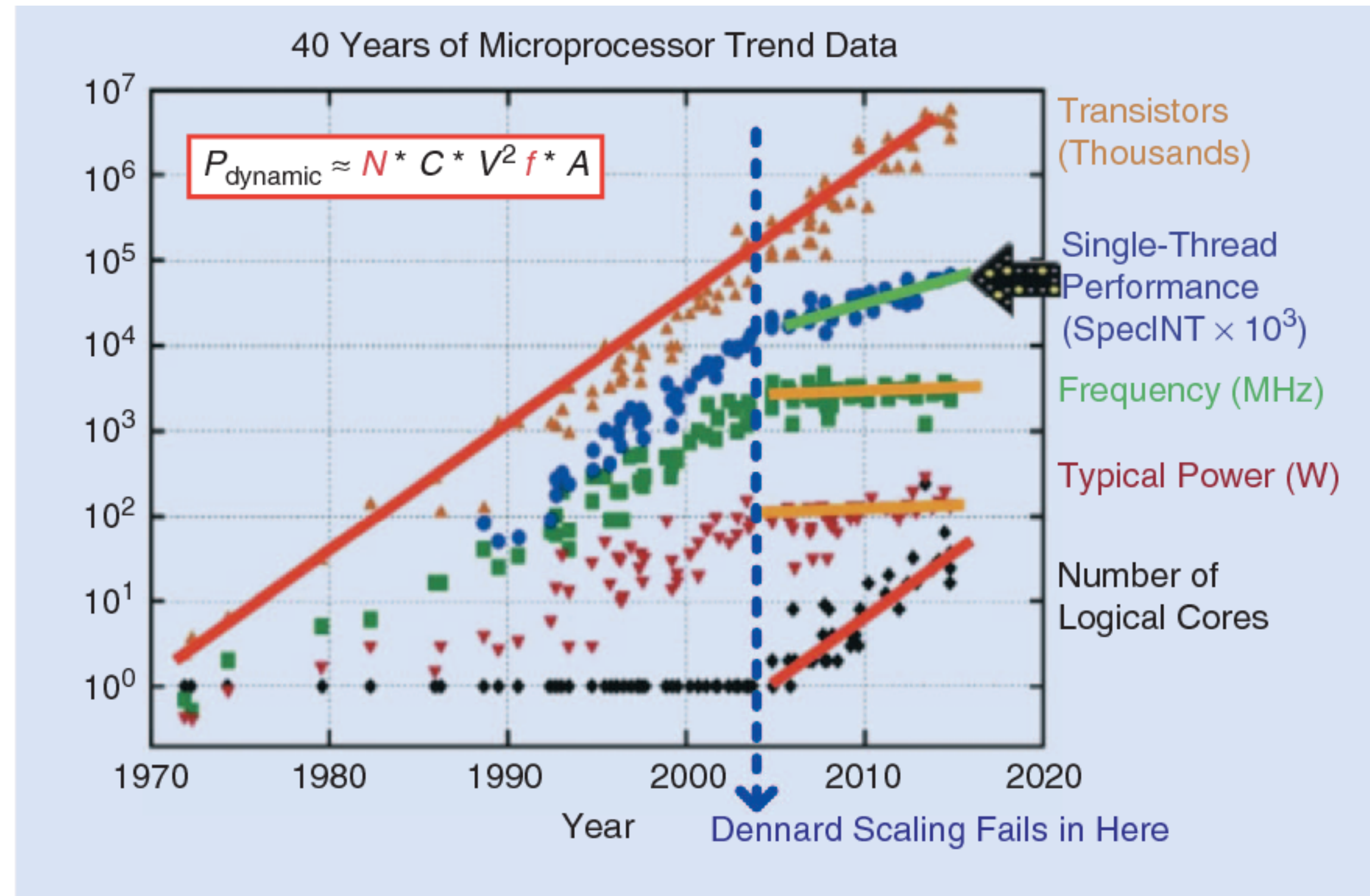

FIGURE 1: The Dennard scaling failed around the middle of the 2000s [24].

Performance increases only by adding more cores or by architectural improvements.

Ro-Micro | From Intel C4004 to Apple M3 Max

- Technology has evolved a lot, a few orders of magnitude over the last 52 years

- The underlying principles and functions are the same: ALUs, Registers, Memories, Interconnect, Clocks, I/Os

- Divide and Conquer: Hierarchical Approach, Parametrizable Designs, and Reuse

- Architecture and Microarchitecture first: determine use cases, data flow, performance and B/W requirements

- SOCs are huge, but they consists of building blocks with local optimizations

- Data and code compression are heavily used, lossless and lossy
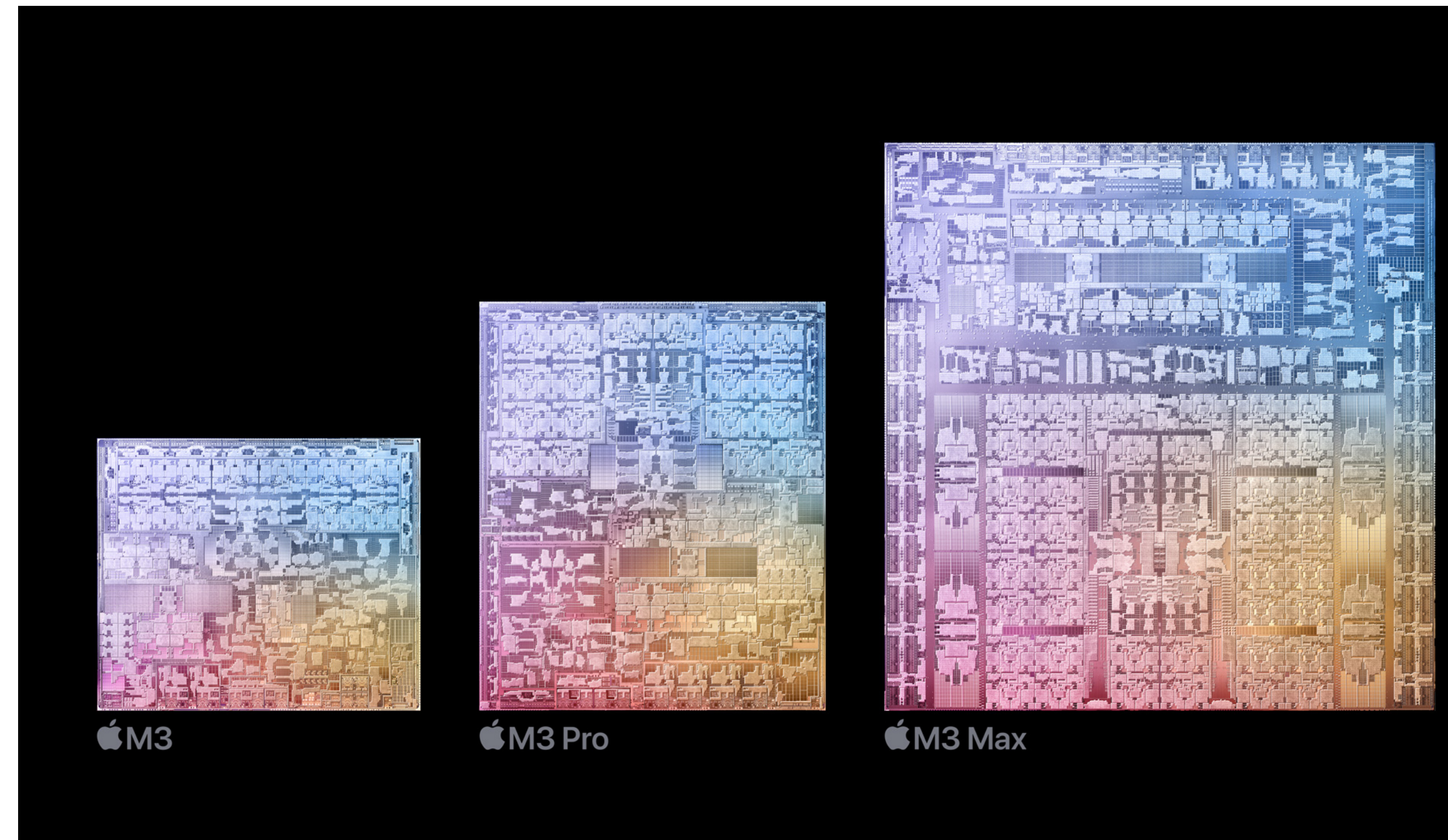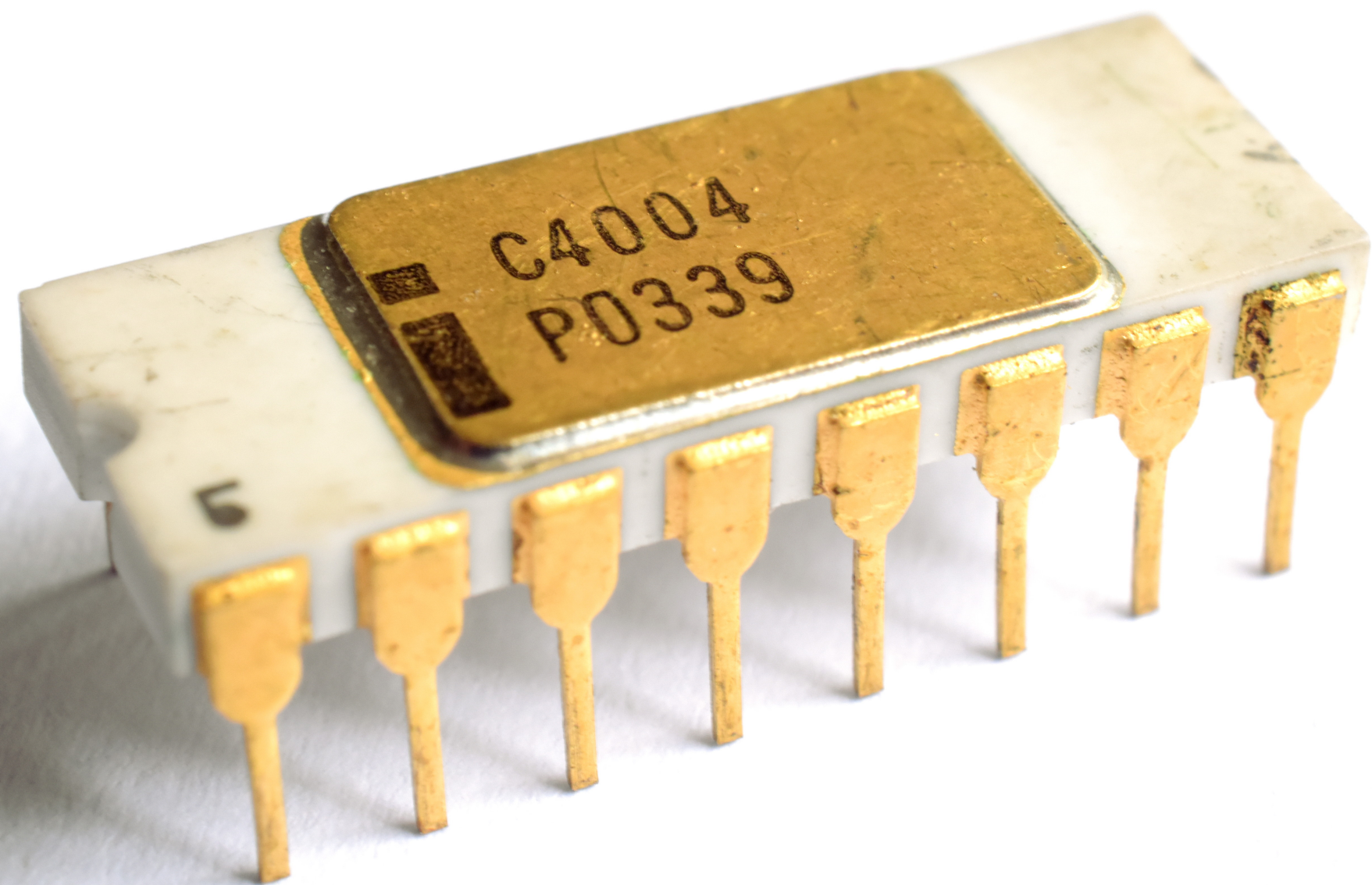
Revolutionary dual-chip performance.

A unique dual-chip design enables the spatial experiences on Apple Vision Pro. The powerful **M2** chip simultaneously runs visionOS, executes advanced computer vision algorithms, and delivers stunning graphics, all with incredible efficiency. And the brand-new **R1** chip is specifically dedicated to process input from the cameras, sensors, and microphones, streaming images to the displays within 12 milliseconds — for a virtually lag-free, real-time view of the world.

Ro-Micro | State of the Microprocessor

- ISA (Instruction Set Architecture) is not that relevant as it was considered in the past

    - x86, MIPS, SPARC, Motorola 68000, PowerPC, ARM, RISC-V

- Market needs, good management, and execution are more important

    - NVDA (Nvidia), APPL (Apple) , AVGO (Broadcom), TSMC vs. INTC (Intel) and many others

- Hardware needs to be fast and simple; Firmware controls the operation and dependencies

- Compiler and tool chain are essential

- For too long industry has relied on Moore's Law

- Like any exponential law, it had to end at some point; it did in 2006

- Like any problem, it brings opportunities

- We are witnessing a Computer Architecture Renaissance

Ro-Micro | What's Next for Microprocessors

- Integration in the past (single chip) -> Disintegration in the future (chiplets)

- Power Consumption is a big challenge

- AI contributes to it; it is a brute force solution that is not sustainable

- Industry needs to do more with less (higher performance with lower power)

- Higher Level of Abstraction

- Domain Specific Processors

- Preserve Data Locality (Data Movement is a lot more costly than Computation)

- Function based Programming

- Hierarchical Caching

- Processor Chaining to minimize access to Memory

Ro-Micro | Technology and Industry Drivers

- **It's all about Disruption**

- **Semiconductor Technology (Process) Drivers**
  - IBM, Intel, Samsung, TSMC

- **Game Consoles**
  - Atari, Sega, Nintendo, Gaming PC, Sony PlayStation, X-Box, Mobile Phones, Tablets

- **Product Drivers**
  - PC (Wintel), Digital Still Camera (Sundisk – George Samachișă), Mobile (Apple), AI (Nvidia – Jensen Huang)

- **Media Delivery**
  - Tapes, Cassettes, VHS & Beta, CDs, Video CD, LaserDisc, DVD, Blu-ray Disc (last physical media support) -> Streaming

- **Industry Disrupters**
  - Pioneers: Shockley Semiconductor Laboratory, Fairchild (Traitorous eight), Zilog, Digital Research (Gary Kildall)
  - Founders (they built Silicon Valley): HP, Apple (before 1990), Intel, Microsoft, Cisco, Qualcomm
  - .com: Amazon, EBay, Yahoo
  - Social Media: Google, Facebook, Instagram, Byte Dance (Tik-Tok)
  - Latest Tech: Netflix, Apple (after 2007), Tesla, Broadcom (Avago), Microsoft (OpenAI), Nvidia

Ro-Micro | Technology Evolution

- **Latest Trends**

  - Own-> Rent, Physical -> Virtual or Artificial (Second Life, Social Media, Metaverse, Robots, AI)

- **Most Companies and Venture Capitalists have a Herd Mentality**

  - Disrupters and trendsetters are in general contrarians; they don't go with the herd, but find their own path
  - Biggest Miss was the Consumers Market which Apple took advantage of

- **AI is a bubble, similar to .com**

  - A lot of capital will be wasted, but some major companies will emerge
  - AI is the ultimate copycat that enables Copyright Infringement and Intelectual Property Appropriation
  - Humans will not be replaced by Robots run by AI (see Federico's talk)

- **Follower vs. Leaders**

  - Don't fight the trend, understand it, find Achilles heel of entrenched players, and disrupt the status quo

- **High Tech and Silicon Valley**

  - Are responsible for most of the economic growth in the last few decades
  - But are ruthless environments
  - Only 10% of start-ups succeed and less than 1% are home runs

- **Andy Grove: Only the paranoid survive**